Ballistics and Trajectory

Marksmanship Master Trainer Course

Action:	Conduct an Introduction to Basic Rifle Marksmanship
Conditions:	In a classroom environment, given a M4-Series Rifle, magazine, 5.56-mm dummy ammunition, indentified training aids and small arms maintenance equipment.
Standards:	Identify how to apply and train Basic Rifle Marksmanship utilizing the US Army Rifle Marksmanship Strategy, the Integrated Weapons Training Strategy, the three step Marksmanship Training Strategy in accordance with applicable command guidance, TC 3-22.9 Rifle Marksmanship M4-Series Weapons and TC 3-20.0 Integrated Weapons Training Strategy.
Learning Domain - Level:	Cognitive - Applying
No JPME Learning Areas Supported:	None

Objective: Students will define the three types of ballistics phases and discuss the effects of ballistics on the round.

Ballistics

Ballistics is the science of the processes that occur from the time a firearm is fired to the time when the bullet impacts its target. Soldiers must be familiar with the principles of ballistics as they are critical in understanding how the projectiles function, perform during flight, and the actions of the bullet when it strikes the intended target. The profession of arms requires Soldiers to understand their weapons, how they operate, their functioning, and their employment.

The flight path of a bullet includes three stages: the travel down the barrel, the path through the air to the target, and the actions the bullet takes upon impact with the target. These stages are defined in separate categories of ballistics; **internal, external, and terminal** ballistics.

Ballistics

Put simply, ballistics is the study of everything that happens to the projectile from the time the primer is struck by the firing pin until the projectile comes to a complete stop.

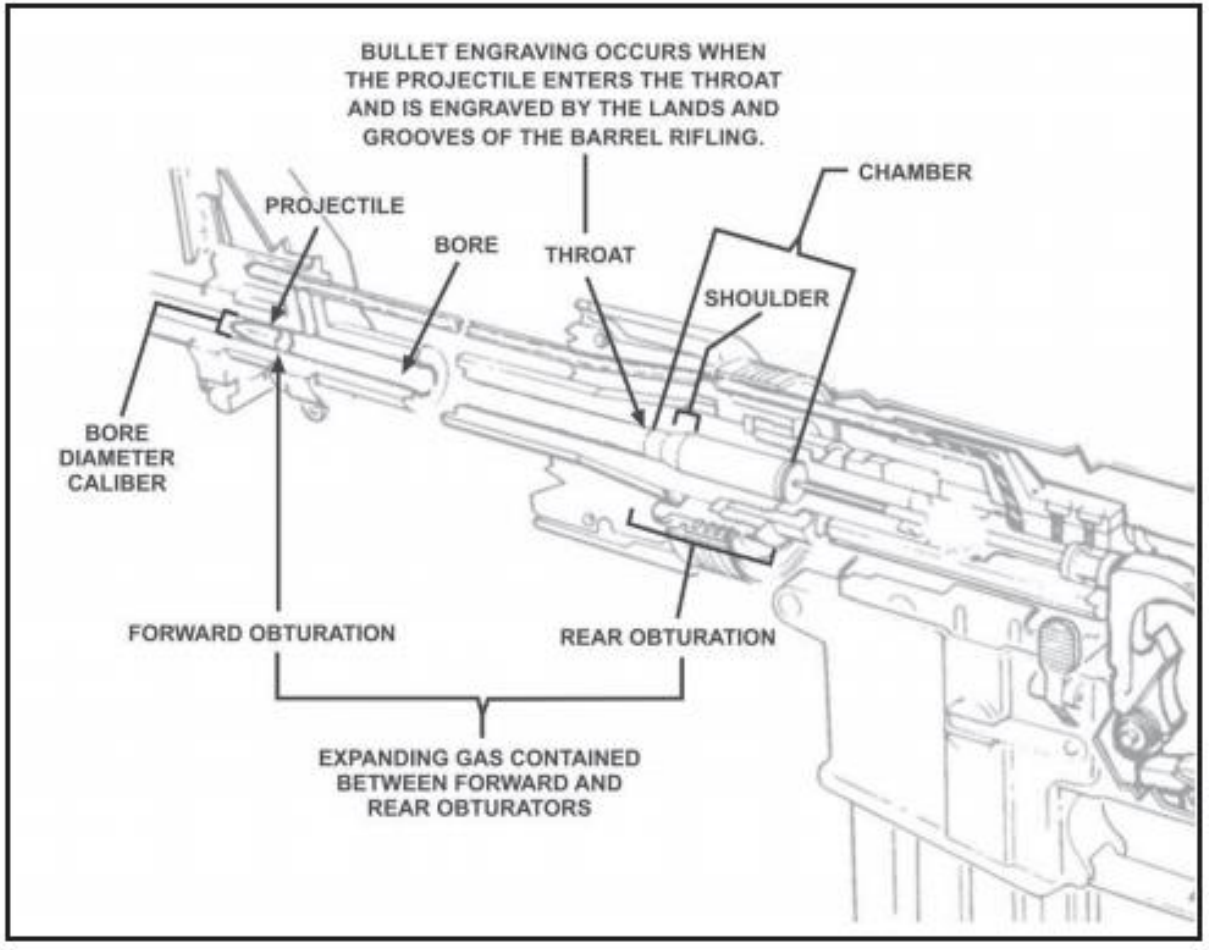
There are three phases in ballistics:

1. Internal
2. External
3. Terminal

Internal Ballistics

Internal ballistics is the study of the propulsion of a projectile. **Internal ballistics begin from the time the firing pin strikes the primer to the time the bullet leaves the muzzle.** Once the primer is struck the priming charge ignites the propellant. The expanding gases caused by the burning propellant create pressures which push the bullet down the barrel. The bullet engages the lands and grooves (rifling) imparting a spin on the bullet that facilitates stabilization of the projectile during flight. Internal ballistics ends at shot exit, where the bullet leaves the muzzle.

Internal Ballistics



External Ballistics

External ballistics is the study of the physical actions and effects of gravity, drag, and wind along the projectile's flight to the target. It includes only those general physical actions that cause the greatest change to the flight of a projectile. **External ballistics begins at shot exit and continues through the moment the projectile strikes the target.**

External ballistics includes the path of the bullet in flight, also known as Trajectory.

External Ballistics

A. Gravity and air resistance have a constant and continuous effect on a bullet passing through the air

B. This constant effect causes the flight (trajectory) of the bullet to be a definitive and uniform arc.

C. A common cylindrical bullet has no loft capabilities. It never rises under its own power.

D. The main purpose of the spin that is imparted upon a bullet is to keep the projectile from tumbling end over end.

E. A bullet fired from a true horizontal barrel begins to slow down and fall towards the earth immediately upon leaving the muzzle of the weapon.

External Ballistics

A bullet flying through the air (WITHOUT WIND) is acted upon primarily by two forces, which change the direction and velocity of its motion.

These two forces are:

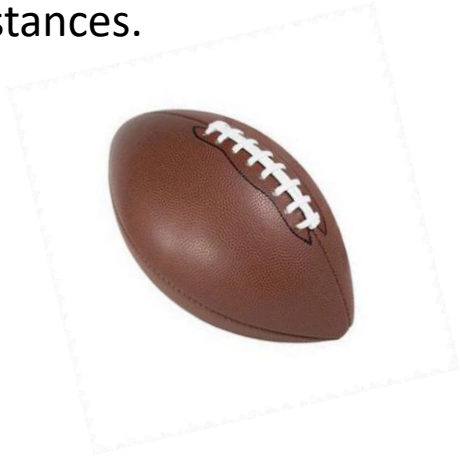
1. Gravity, which causes the bullet to fall towards the earth
2. Air Resistance, which causes the bullet to slow down and tumble

External Ballistics

We as shooters counter these forces by:

1. Increasing the angle of departure by elevating the muzzle to counter the effects of gravity
2. Imparting spin and high velocities on the bullet to counter air resistance and allow the bullet to fly in a nose forward manner at far distances.

This process is very similar to throwing a football.



Trajectory

To understand trajectory, you must first understand these three things:

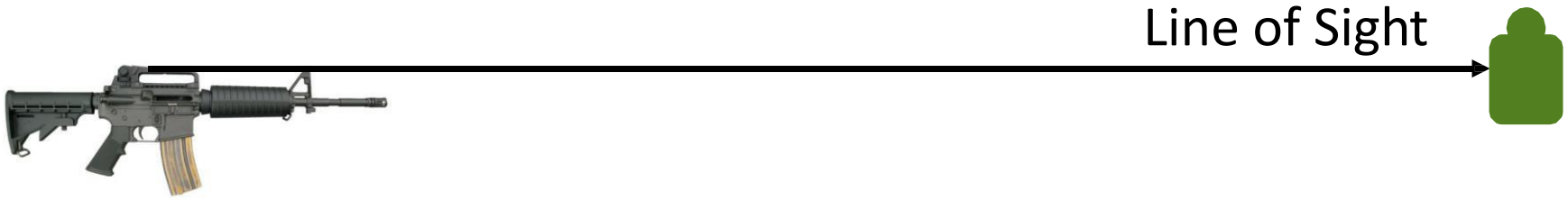
- Line of Sight
- Line of Bore
- Path of the Bullet (AKA Trajectory)

Trajectory

Line of Sight

Line of Sight:

This is what the shooter sees behind the sights and can be illustrated by drawing a straight imaginary line from your eye through the rear and front sights out to the target. This is how you aim.

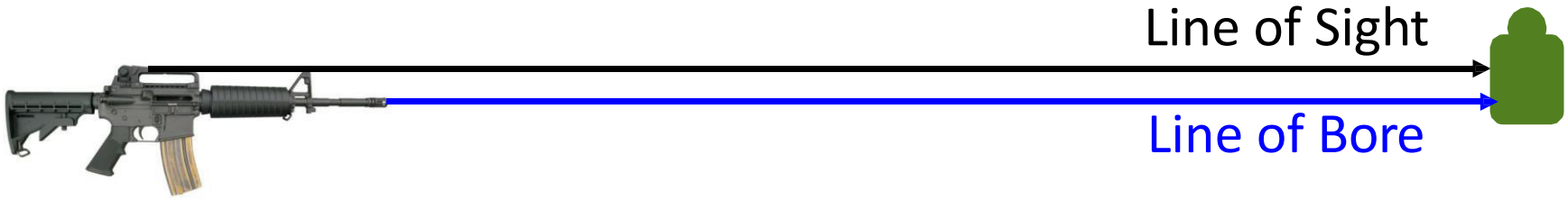


Trajectory

Line of Bore

Line of Bore:

This is a straight imaginary line that is drawn from the muzzle of the rifle out to the target.



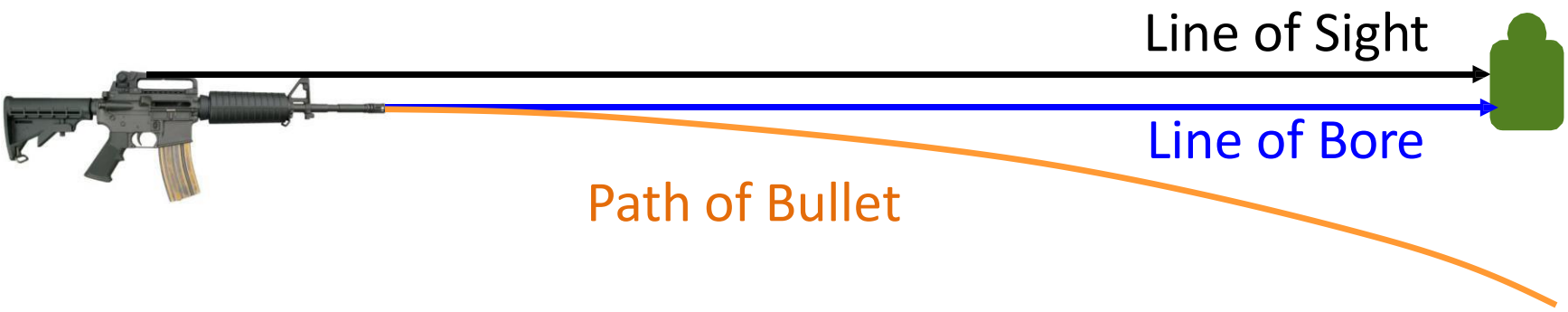
Trajectory

Path of the Bullet

Trajectory:

This is the path that the bullet will take when it is fired from the rifle.

Clearly the path of this bullet does not lead to the target. What needs to change?



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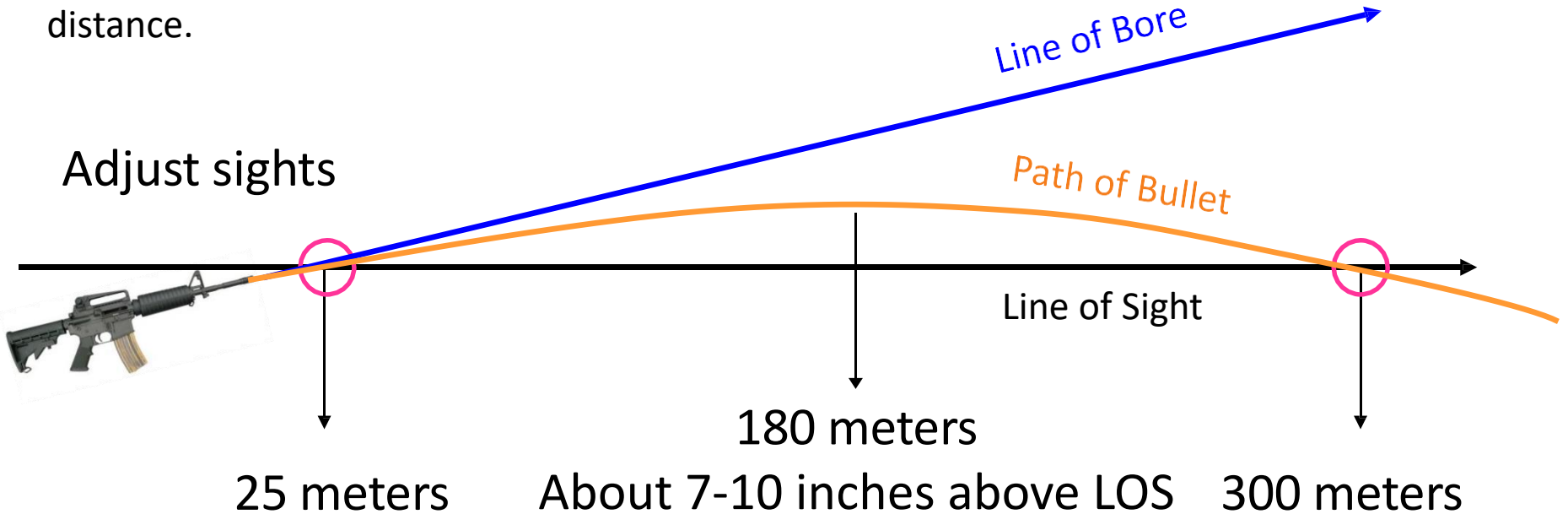
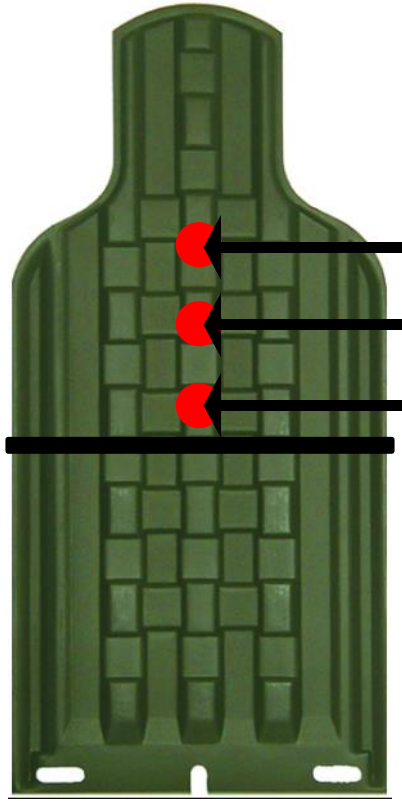
Trajectory

To make our bullet hit the target, we must angle the barrel up. This causes the bullet to travel in an arc. We zero the rifle so that the path of the bullet crosses our line of sight at the desired distance, in this case 300 meters. With an M4 firing standard ammunition, this causes the path of the bullet to intersect with the line of sight at 25 meters also, which is why we can begin the zeroing process with a 25 meter zero before we confirm at distance.



Trajectory

POI and POA with a 300m Zero



150m/200m, about 7 in above POI

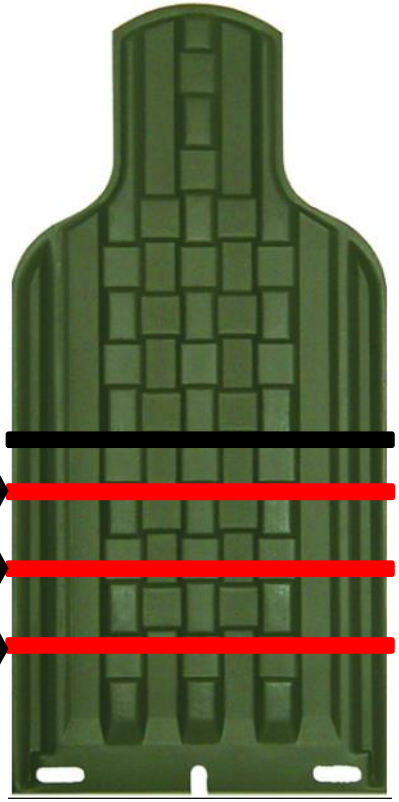
100m/250m, about 5 in above POI

50m, about 2 in above POI

50m, about 2 in below center

100m/250m, about 5 in below center

150m/200m, about 7 in below center

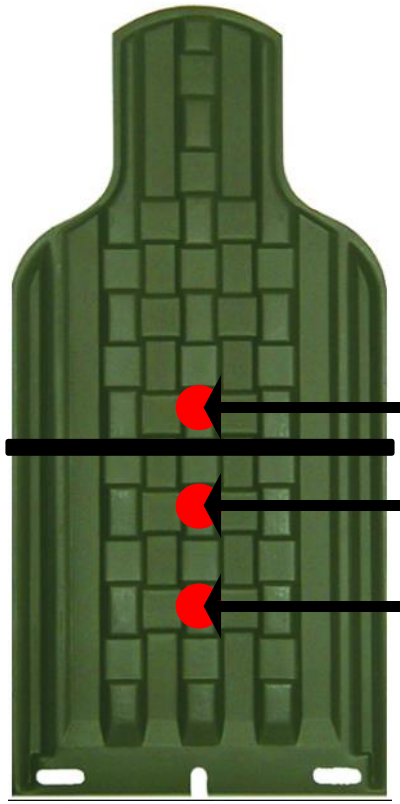


Center Hold POI

Hold for Center POI

Trajectory

POI and POA with a 200m Zero



Center Hold POI

100m, about 10 in above center

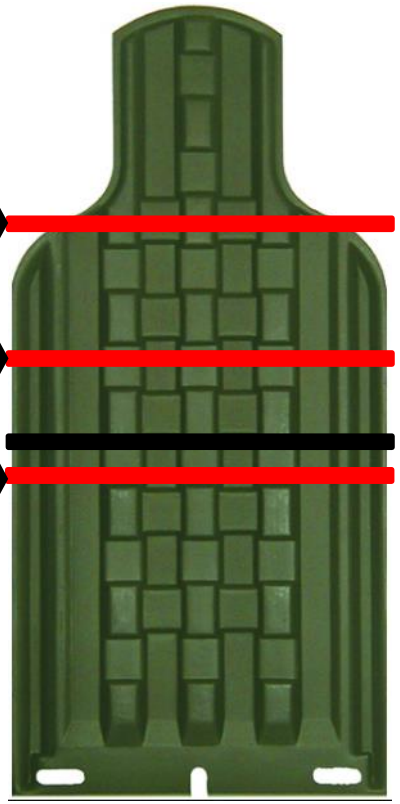
250m, about 4 in above center

100m/150m, about 2 in above POI

100m/150m, about 2 in below center

250m, about 4 in below POI

300m, about 10 in below POI



Hold for Center POI

Trajectory

3 Branches of Trajectory:

1. Ascending (Rising)
2. Maximum Ordinate (Summit)
3. Descending (Falling)

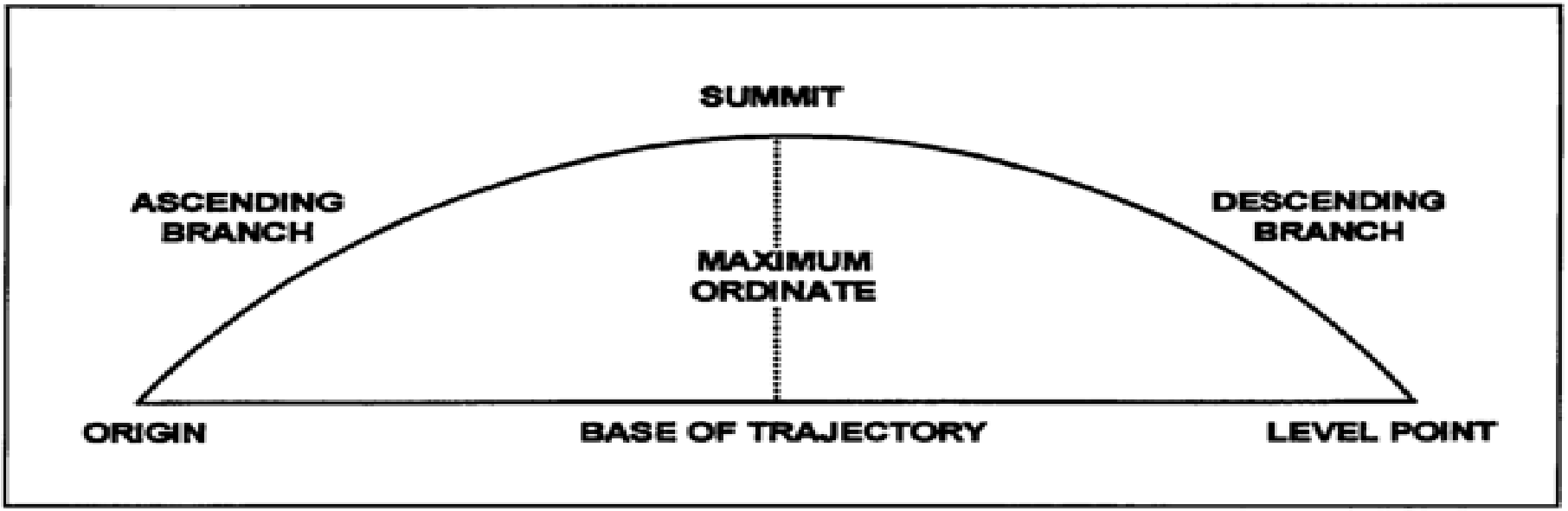
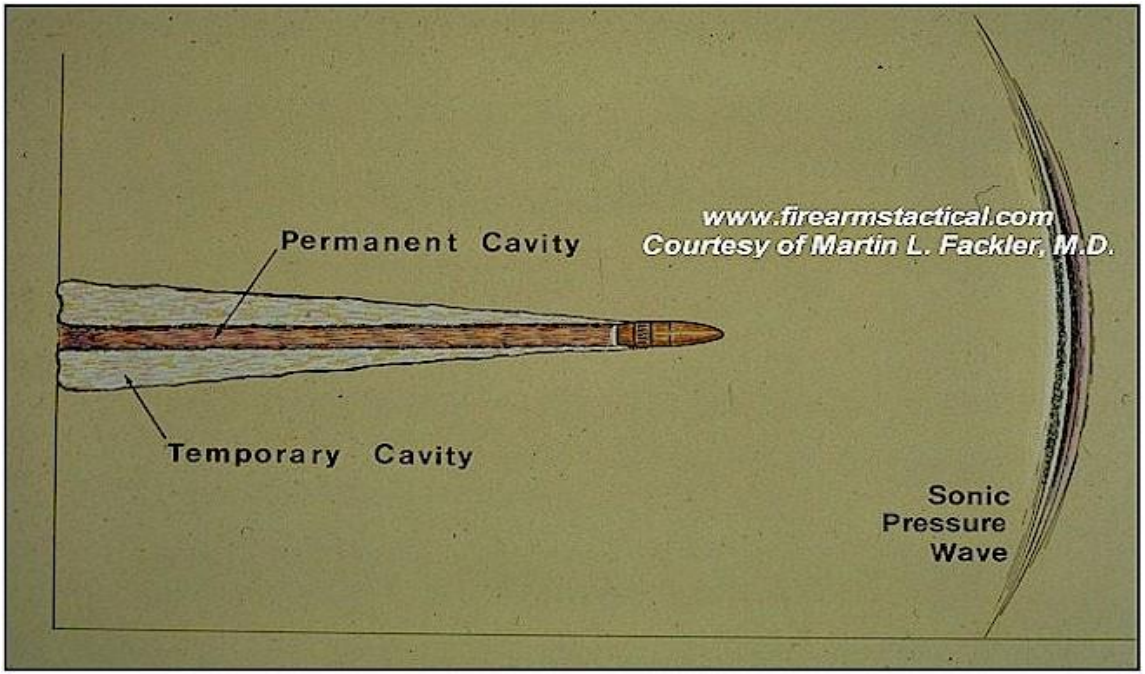


Figure 3-5. Intrinsic Elements of the Trajectory.

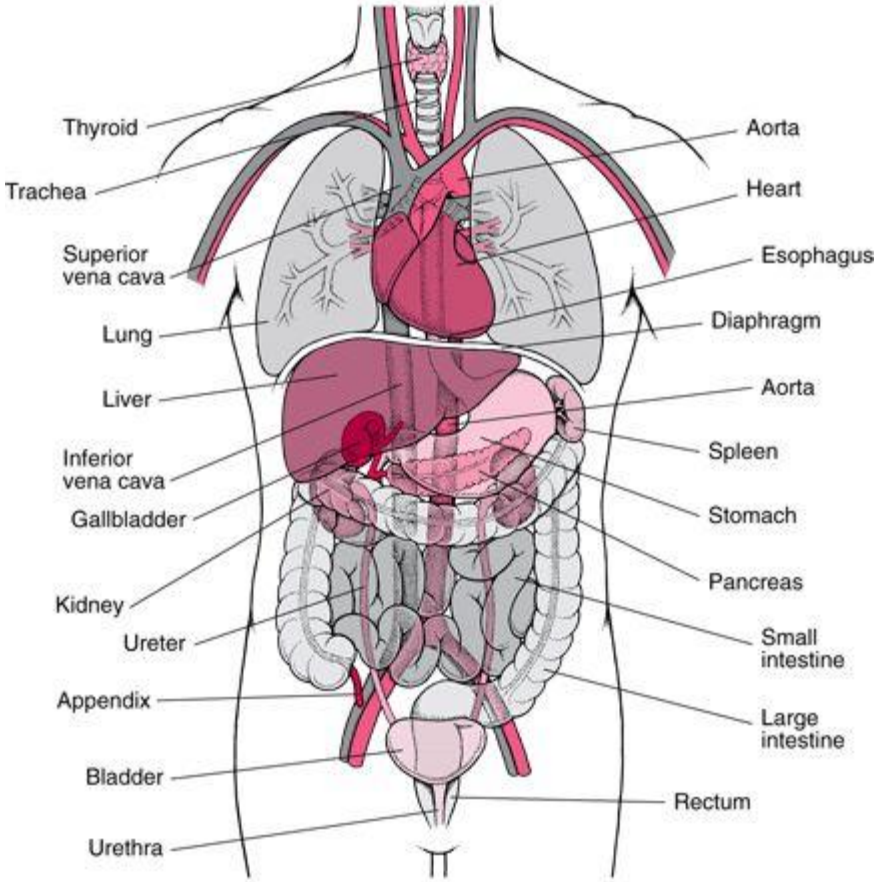
Terminal Ballistics

Terminal ballistics is the science of the actions of a projectile from the time it strikes an object until it comes to rest (called terminal rest). This includes the terminal effects that take place against the target.



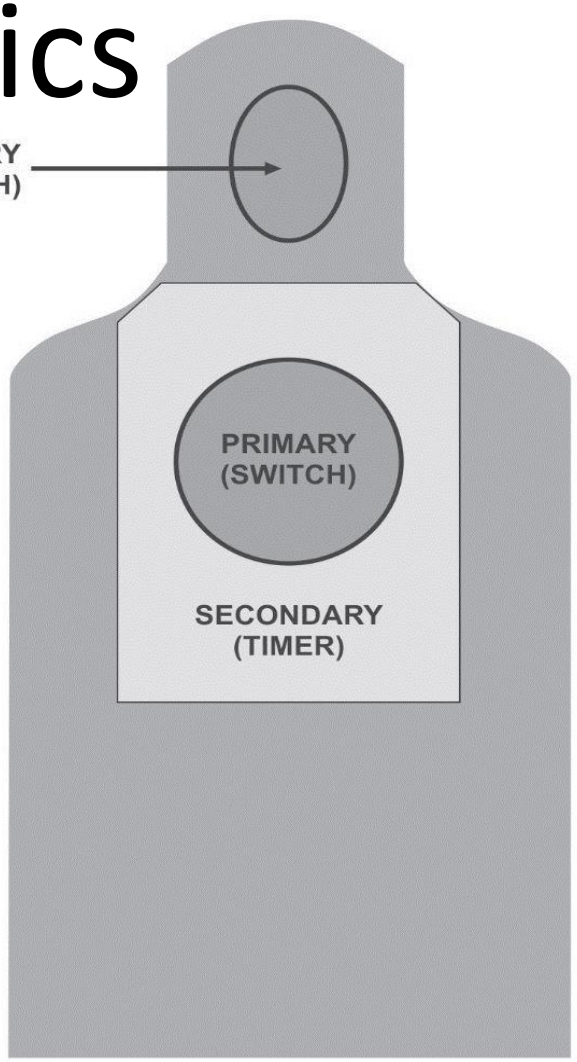
Terminal Ballistics

Terminal Ballistics



Terminal Ballistics

Lethal Zones



The Soldier's primary point of aim at any target by default is center of visible mass. This allows for a tolerance that includes the greatest margin of error with the highest probability of a first round hit. The combat conditions may require more precise fires at partially exposed targets or targets that require immediate incapacitation.

Ideally, the point of aim is anywhere within a primary switch area. This point will maximize the possibility of striking major organs and vessels, rendering a clean, one shot kill.

Terminal Ballistics

Hydraulic Shots

Hydraulic shots, or “timers,” are impacts on a target where **immediate incapacitation is not guaranteed.** These types of ballistic trauma are termed “timers” as that after the strike of the bullet, the damage caused requires time for the threat to have sufficient blood loss to render it incapacitated. Hydraulic shots, although ultimately lethal, allow for the threat to function in a reduced capacity for a period of time.

For hydraulic shots to eliminate the threat, they must cause a 40 percent loss of blood within the circulatory system. If the shots do not disrupt that flow at a rapid pace, the target will be able to continue its mission. Once two (2) liters of blood are lost, the target will transition into hypovolemic shock and become incapacitated.

Terminal Ballistics

Circulatory Shots

Circuitry shots, or “switches,” **are strikes to a target that deliver its immediate incapacitation.** Immediate incapacitation is the sudden physical or mental inability to initiate or complete any physical task. To accomplish this, the central nervous system must be destroyed by hitting the brain or spinal column. All bodily functions and voluntary actions cease when the brain is destroyed and if the spinal column is broken, all functions cease below the break.